Jordan Phil Sc. 16 (1949) p269

it is attack on V. Neumann's subjectivism

— Irreversibility is due to measurement

not to the mind of the observer.

[illegible] evidence due to [illegible]

method for α-particle emissions.

at T=0°K coherence would return.

refers to Margenau Phil. Sc. 4 (1937) p337

distinguishes measurement from state preparation

for the first time.

Translations required

P. Jordan	Zeits. f. Phys. 44	473	(1927)
O. Klein & P. Jordan	ibid 45	751	(1927)
E. Wigner & P. Jordan	ibid. 47	631	(1928)
V. Fock	ibid 75	622	(1932)
Jordan & Pauli	ibid 47,	151	(1928)
Heisenberg & Pauli	ibid 56	1	(1929)
	" 59	168	(1930)

H.A. Kramers Quantum Mechanics. Translated Ter Haar.

has short section on Kramers well on renormalization on - p. 453. Historical notes are given.

Amsterdam — North Holland 1956 (?)

Also section on Field theory, Corpuscular theory of Radiation.

If says one cannot define current operator in relativistic Boson fields - hence one cannot speak of particles in other sense in the same sense as in N.R. Q.M. of a system of point particles.

Rel. theory overlays the equivalence of other features energy only reasonable has other features (& no comments)

Aharonov, Bergmann, Lebowitz

'Time Symmetry in the Quantum Process of Measurement'

P. R. 134 (1964) p. 1410.

See die Erwähnung in Schilpp vol. Rudolf Carnap

The Interpretation of Quantum Mechanics

J. Bub. D. Reidel. 1974

very good account of hidden variable theories & q. logic with some discussion of model theory for q. logic. very good discussion of the significance of the underlying Tarski algebra → examples with algebra of sets (of maximal set of props implied by given prob. i.e. algebra of ultrafilters) this is content of Stone's representation theorem..

Bub Found. Phys. 3 p. 29 (1973)
Refutation of Bell-Wigner

rejects $p(s/t) = p(s \wedge t)/p(t)$
does not hold for incompatible observables
nor even for compatibles
due to intransitivity.
we must have a non-Boolean rule for conditional probs. in the Boolean phase space theory.
Prob. theory is strongly non-Boolean
cannot be interpreted as a calculus on Boolean logical space.

Fine rejects Bell-Wigner locality result p. 257 – 259
refers to Bob. Foun. Phys. 3 (1973) 29–44.

$\boxed{\text{Synthese Dec. 1974}}$

Lutzer criticism of Kochen Specker proof p. 331 – 372.

Cartwright on Macroscopic dowaltes p. 229 – 242.

Wigner's argument $A_1\ A_2\quad B_2\ B_3\quad \{A_i\ B_j\}=0$.
spectrum is $\{1,-1\}$ all 4 operators.

$$P^{\phi}_{A_1,B_3}(1,1) \leq P^{\phi}_{A_2 B_3}(1\ 1) + P^{\phi}_{A_1,B_2}(1,1).$$

$A_i = \sigma_A \cdot d_i \quad i = 1, 2$ three d's $d_1\ d_2\ d_3$.
$B_j = \sigma_B \cdot d_j \quad j = 2, 3.$

Lutzer criticises Kochen Specker
(1) Commensurability can be defined until different "loci"
observable – then partial operations are
not preserved $(f_1+f_2)B \neq (g_1+g_2)C$ even if $f_1(B)=g_1(C)$, $f_2(B)=g_2(C)$
(2) Commensurability of two for ... doubles
if B or C can be measured – not true Lutzer
claims for the ... example.

Fine's makes the point essentially
that joint probs in QM are not to be derived
from joint probs in H.V. phase space of hidden
variables – this association depends on the
product rule, which may collapse
– better to regard every quantity as having
a value but joint probs given by Q.M. – each
variable is in its own sample space.

Gleason (after Varadarajan)

$\langle F \rangle = \mathrm{Tr}\, F U \qquad \underline{U = \sum \lambda_i P_i}$

Frame function $\sum_a f(P_a) = W$ for any orthonormal basis.

$f_U(x) = \langle U \rangle$.

Regular frame f. if $\exists\, U$ s.t. $f = f_U = \langle U \rangle$.

$\mathrm{Prob}\, f = \langle D \rangle$. $\qquad P^2 = P \qquad$ ~~Tr AB=~~

$\sum \mathrm{Prob} = \underline{\mathrm{Tr}\, U}$. $\qquad \mathrm{Tr}\, P = 1 \ldots$

$P^2 = P \qquad \mathrm{Tr}\, AB = A_{ij} B_{ji}$

$\langle P \rangle = \mathrm{Tr}\, P$.

⇒ 1. Say continuous frame function on R^3 is regular.
by harmonic analysis.

2. Every frame function is continuous

$\mathrm{Tr}\, UAU^{-1} = \mathrm{Tr}\, A$

Wess, Zumino Supergravitation N. Phys. B70 (1974) p. 39-50.

discuss supergauge transformations in four-dimensional space time. - similar to a Lie algebra.

refer to Neveu, Schwarz. N. Phys. B31 (1971) p. 86.

refer to Koba, Nielsen N. Phys B.10 (1969) 633

1) Combley, Picasso Phys. Rep. 14 p. 1 (1974)
the Muon (g-2) precession experiments.
very good account
of all muon experiments
refer to Lautrup et al. Phys Rep
, Rich, Wesley R.M.P. for earlier summaries

See for dual resonance Rambelstam Phys. Rep. 13 (1974) p. 259.
, strings Rebbi .. 12 (1973) p. 1

M. Jammer: <u>The Philosophy of Quantum Mechanics</u> 1974

gives very detailed reference to Interpretations of QM.
begins with <u>Schrödinger's</u> electromagnetic interpretation by analogy
with <u>wave phenomena</u>, also <u>hydrodynamic</u> analogy of Madelung

De <u>Broglie</u>'s Double solution.
then discusses Indeterminacy Relations in Ch. 3.
refers to <u>Kennard</u> for derivation of uncertainty relations
[illegible] 4 new for hydrogen. (Zs. <u>69</u> (1929) p. 573)
<u>Ch. 4</u> discusses Bohr on Complementarity, the Como Lecture, 1927.
refers to Weizsäcker's distinction between <u>circular</u> comp
(never realised in classical model), <u>parallel</u> comp (are realised
in classical model)
<u>ch V</u> is on the Bohr-Einstein debate.
5th Solvay Conference 1927.
Bohr says his philosophy derived from Einstein's method
on relativity. E. comment "A good joke should not be
repeated too often" (said to Frank).

6th Solvay Conference. 1930.
photon in a box $\Delta E \Delta t$ expt
weighing clock

Bohr's reply. used uncertainty in clock rate. from G.R. ?

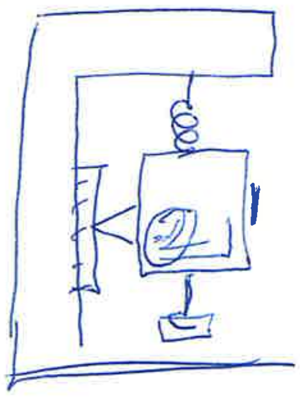
ΔT related to $\Delta q \to$ position of clock

related to Δp momentum of clock.

must be smaller than $Tg\Delta m$.

where Δm is error in weighing

$\Rightarrow \Delta T \Delta E > h$.



So G.R. $\Rightarrow$ consistency of Heisenberg relations

we cannot reverse this implication

But $\sim$(G.R.) $\Rightarrow$ $\sim$(Heisenberg)

$\therefore$ Heisenberg $\Rightarrow$ G.R.

But we can also derive consistency by assuming

unrelated mass of box in a collision $\to$ indeterminacy

in velocity of box $\to$ ΔT as required.

J. refers to many different interpretations of what $\Delta E \Delta T$

signifies – in particular refers to the Mandelstam–Tamm

interpretation (as followed by Messiah)

ch VI deals with E.P.R.

Replies from Kemble, Bohr, Schrodinger (+cat), Furry 3
Margenau.
J. refers to two unresolved arguments:—
(1) Epstein Am. J. Phys. 13 (1945) p. 127 concerning time dependence.
(2) Cooper. Proc. Camb Phil. Soc. 46 (1950) p 614.
Separation in space often introduces back to new defn of momentum operator. EPR argument breaks down:
either (1) systems cannot be separated
or (2) if they are they no longer have self-adjoint ops for the momenta
J. then refers to Sharp (systems never separate)
Kruger says $q\ p$ can have simultaneous values
$\Delta p\ \Delta q$ refer to ensembles only
ch 7 deals with hidden variables
Stance they are generally a hidden variable theory.
deals with Von N's proof
Bohm's 1952 hidden variable theory which starts from hydrodynamic analogy write $\psi = Re^{iS}$
(of Madelung)

Then came work of Gleason showing that additivity of expectation values for commuting operators alone is sufficient.
Jauch & Piron recast proof in terms of lattice theory.
Then Bell (1966) gave his example of spin ½ hidden variables (1963)
— also his 1964 proof of non-locality for coherence of 2 particles.

Kochen & Specker proof given in a simplified version
Partial algebra defined. Mapping $f: P \to R$ preserves partial algebra, so leads to a homomorphism of partial algebra into R, or by restriction algebra (idempotents) $\frac{2}{\text{Boolean}}$ Boolean algebra $\{0,1\}$ $(\cong \mathbb{Z}_2)$. But this is found to be impossible for dim ≥ 3.

Special example. $J^2 = J_x^2 + J_y^2 + J_z^2$ $x=2,\ l=0,\ s=1$
for orthohelium $J_x^2, J_y^2\ J_z^2$ & J^2 all commute.
$J^2 = 2$
Hence one only of J_x^2, J_y^2, J_z^2 is zero
Simple proof due to ~~F~~ Friedberg.
α-prop for direction α say $L_{\parallel \alpha} = 0$.
Then only one of 3 orthog. α-props is true (1)

Now $x+y$, $x-y$, z are orthog. also $x+z$, $x-z$, y. 5

Hence $x+y$, $x-y$, $x+z$, $x-z$. cannot all be false.

Now each is orthog. to $d_1 = y+z+x$ and $d_2 = y+z-x$.

So d_1 & d_2 cannot both be true.

angle between d_1 and d_2 is $\cos^{-1}(\frac{1}{3}) \simeq 70^\circ = \alpha$

So Two d-props making an $\angle \alpha$ cannot both be true.

Now take d_3 in xy plane $\angle \alpha$ with y.

If d_3 is true z is false, ~~Hence~~ and y is false.

and Hence. x is true.

or if $\beta = \pi/2 - \alpha$.

Then Two d-props which make an angle β ($\simeq 19^\circ$) with one another.

Hence every d-prop $\Rightarrow$ every other d-prop.

So if $\angle d = 0$ in one direction, it is 0 in all directions, which contradicts (2).

But we have assumed truth value of a d-prop does not depend on which other d-props are being measured - once we select different triads - then we have truth-values might alter - then we have Bohm's theory works (cf. de Broglie)

Finally there is a discussion of Von Stalrod 6
"proof" of EPR non-locality and Tracker's comments
and Friedman, Clauser
and Clauser, Horne, Shimony, Holt ~~for proof of~~
experimental check on Bell's inequality

ch. 8 clas. and Q. Logic

3-valued logic due to Lukasiewicz (1920).

Non-Distributed Logic Birkhoff, Von Neumann (1936)
discussion of Popper's (1968) paper. Popper misunderstood
what von N. meant.

many-valued logic
Logic is ~~a theory of reality~~ empirical or
"relativity of logic". promoted by French school.
P. Hertz, G. Bachelard, F. Gonseth, Z. Bouligand in
1930's. → Février's 3-valued logic
[also Lewis, Hahn, Carnap in the 30's] → Reichenbach (1944) in his
book on Philosophic Foundations of Q.M.
attacked by Turquette author of standard work on
many-valued logic (1952)

Refers to Nagel. "Logic without Ontology" rep. in Feigl, Sellars p. 191 (Readings in Philosophical Analysis)

Born criticized Reichenbach in 1948 for "explaining" 3-valued logic using 2-valued logic.

But R. was supported by Putnam. (1957)

J. also discusses Segal's algebraic approach to QM (developed from Jordan) and Roohey's axiomatic treatment (1963) – developed by Jauch & Piron at Geneva. (1969).

Different approach is Mittelstaedt (1959 onward) following logical ideas of P. Lorenzen. (operative logic)

In section 8.6 J discusses relation of quantum logic to logic. Non-standard logic should be used to formalize arguments in the language. We should re-write Principia Mathematica in non-standard terms (cf Heyting–Brouwer and intuitionist logic)

Piron showed that $a \leq b$ (or $a \Rightarrow b$) is not a yes-no proposition. If $a \leq b$ functions like $\Rightarrow$ since it implies whenever a is true, b is true, but we can give no meaning to $a \leq (b \leq c)$ which would

converted to $a \to (b \to c)$
cf Piron Helv. Phys Acta. 37 (1964) p. 439.
But there may be generalization of $a \to b$ which reduces to latter on Boolean lattices. cf Mittelstaedt Z. f. Naturf. 27a (1972) p 1358.
But Jauch & Mittelstaedt both show derivation of Q. Logic from ordinary logic.
But D. Finkelstein & H. Putnam (Boston Studies 5) do regard Q. Logic as a new full-fledged logic similar to non-Euclidean geometry replacing Euclidean.
But for endorsed Putnam's views.
Finkelstein's introduces operational defn of connectives using filters. But $a \cap b$ involves ∞ set of filters which is not experimentally possible (Heelan's criticism. Synthese 21 (1970) p 1)
Suppes suggests Q. logic on probabilistic grounds - absence of joint distributions. ⟹ Logic is non-classical. Phil. Science. 33 (1966) p. 14
But Suppes criticised by Fine (1968)

Putnam says $q_1 \cup q_2 \ldots$ ideal & $p_1 \cup p_2 \ldots$ ideal

But $q_1 \cap q_2$ is always false.

q is incompatible with p_i for all times, all i.

But is not incompatible with $(p_1 \cup p_2 \cup \ldots)$

i.e. is correct deduction since $(q_i \cap p_1) \cup (q_2 \cap p_2)$ —

is false then $q_i \cap (p_1 \cup p_2 \ldots)$ is false.

Indeed if q_i is true then individual q_i cannot be combined with p_1 or $p_2 \ldots$, but it can be combined with $p_1 \cup p_2 \ldots$. The distribution is for non-distributive models itself.

Heelan tried to refute Putnam by Putnam in 1968 — uses classical logic to prove classical logic is wrong (?).

We also have work of Watanabe (Boston 5 etc) who says correspondence between conventional logic & Boolean lattice is a consequence of Frege Principle (Every predicate determines a set)

So predicational calculus → set theory → Boolean algebra.

W. rejects Frege's Principle (cf Russell's paradox)

Frege Principle breaks down when object & observer interact as in QM & psychology (cf also Locke's 2nd qualities which depend on observer as well as object) 10

So W, follows Peirce Principle. Implication is basic logical operation. W also derives ∧ & ∨ from → and allows for possibility of non-distributivity.

There is a domain of inference where usual logic applies so usual logic can function as a metalogic in terms of which the new logic can be explained.

cf also Zadeh's theory of fuzzy sets (1965)

In final section J. refers to work by Van Weizsäcker to derive laws of QM as conditions under which experience becomes possible (cf Kant) and Ludwig who regards macrophysics as preeminent. Q.M. is not the most fundamental theory. "It is hard to believe that Q.T. of 10^{24} atoms is actual theory of a table.

In Ch. IX J. discusses stochastic interpretations 11
refers to Wigner distribution, Rosen's paper.
also Margenau, Cohen - Von Bopp and others.

In ch X J. discusses statistical interpretations
adopted by Kemble in his book on QM.
→ Popper and Landé.
Park has attacked single state concept. Am. J. Phys. 36 (1968) p 211.
(also Ballentine. But Groenewold disagrees,
although keeping to the statistical interpretation..
→ (relies on concept of the statistical operator.)

In final chapter XI J. discusses problem of measurement.
(1) Von N's theory is explained.
(2) London, Bauer elaboration (1939) stress role
of mental activity.
J then discusses Margenau. → (Phil. Sci. 4 (1937) p. 337.
Measurement may determine
a state after or reveal a state before (cf also
Landau, Peierls (1931) who showed in general
that measurements perturb state (extensions of
Von N. theory by Wigner, Araki, Yanase)

Landé concluded of position measurements could be repeated with same result. 12

Jordan (Phil. Sci. 16 (1949) p269) introduced idea that apparatus must be macroscopic → irreversibility → statistical mechanics is key to measurement problem.

This idea was pursued by Ludwig (in his book Grundlagen der Quantenmechanik 1954 et al.)

L. introduced macroscopic observables and discussed how classical physics can be "extracted" in limit $h \to 0$.

J refers to Van Kampen's work.

Then to D.L.P. (prompted by Ludwig) supported by Rosenfeld, but criticised by J and Wigner's Yanase (1967), also Bub (1968)

J. then has digression on Renninger's "negative-result measurements".

J. then discusses Wigner's proposed effect of mind on physics.

J. then discusses Margenau's Latency theory. 13

refers to L. Durand Phil. Sc. 27 (1960) p. 115 for discussion how " peculiarly quantum-mechanical effects are small relative to the accuracy with which classical observations may practically be made.

But Durand has been criticised by Fine (Proc. Camb. Phil. Soc. 65 (1969) p 111)

J then turns to Everett's Many-Worlds theory developed by de Witt, , Graham — yields its own interpretation. supported by Wheeler but incredible.

Finally J. refers to Fine's unfinished proof for possible to Realism. P.R. D2 (1970) p2783. developing on work of ~~A's~~ Wigner d'Espagnat, Earman's Philosophy. and finally gives reference to George, Prigogine's Rosenfeld

Final comment on Rosewell. "A new look at the Q.M. problem of Measurement. Am. J. Physics 40 (1972) p. 1431, who says new objective version of QM must be developed which does not incorporate the notion of measurement in its basic postulates at all.

Quote from Joubert "It is better to debate a question without settling it than to settle a question without debating it"

Jammer Philosophy of Quantum Mechanics

Bell's hidden-variable example:

$A = \alpha + \beta \cdot \sigma$ α, β real. Possible results for A

$a_1 = \alpha + |\beta|$, $a_2 = \alpha - |\beta|$. Take $\psi = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$

$\langle A \rangle = \alpha + \beta_z$

then $a(\lambda, \psi) = \alpha + |\beta| \operatorname{sgn}(\lambda|\beta| + \frac{1}{2}|\beta_z|)$

$\operatorname{sgn} X$, $X = \beta_z\ \beta_x \beta_y$, 1st non-zero value in this order

Take $\beta_z \neq 0$, $\beta_z > 0$

then $\langle A \rangle = \int_{-\frac{1}{2}}^{\frac{1}{2}} d\lambda \left[\alpha + |\beta| \operatorname{sgn}(\lambda|\beta| + \tfrac{1}{2}|\beta_z|)\right]$

$= \alpha + |\beta| \left\{ \left[-\lambda\right]_{-\frac{1}{2}}^{-\frac{1}{2}\beta_z/|\beta|} + \left[\lambda\right]_{-\frac{1}{2}\beta_z/|\beta|}^{1/2} \right\}$

$= \alpha + |\beta| \left\{ \frac{1}{2} + \frac{1}{2}\beta_z/|\beta| + \frac{1}{2}\beta_z/|\beta| - 1/2 \right\}$

$= \alpha + \beta_z$, similarly for $\beta_z < 0$.

Bell's Inequality $A(a, \lambda)$ is result of $\sigma(1) \cdot a$ (± 1)

$B(b, \lambda)$ is .. $\sigma(2) \cdot b$ (± 1)

for QM. $P_{QM}(a, b) = \langle \sigma(1) \cdot a\ \sigma(2) \cdot b \rangle = -a \cdot b$ for singlet state.

$P_{h.v.}(a, b) = \int \rho(\lambda) A(a, \lambda) B(b, \lambda)\, d\lambda$

Defn of Hidden variable

(1) hidden variables λ, define space Γ

(2) Each ψ is associated with a prob. measure $\rho_\psi(\lambda)$ on Γ.

(3) each observable A is associated with single-valued real function $f_A : \Gamma \to \mathbb{R}$.

(4) M is a measurable subset of $\mathbb{R}$ and μ_ψ^A is a prob. measure such that $\mu_\psi^A(M)$ is prob. value of A lies in M.

then $\mu_\psi^A(M) = \rho_\psi[f_A^{-1}(M)]$

or $$\langle A \rangle_\psi = \int_\Gamma f_A(\lambda)\, d\rho_\psi(\lambda)$$

non-contextual h.v. $f_A(\lambda)$ does not depend on values of other observables which are compatible with A and which may be measured also

local h.v. $f_A(\lambda)$ for measuring A on S_1 in state ψ, λ does not depend on the kind of measurement (or its outcome) performed on a second system S_2, spatially separated from S_1.

Comment on H. Bruce

cp Park: International J. Theor. Physics
$\underline{8}$ (1973) p. 211

More discussion of Park $m_1 \supset m_2$ distinction
— Non-disturbing measurements, failure of projection postulate, reference to Park Found. Phys 1, (1970) p. 23. $\psi\alpha \to \psi\psi_1$, $\psi_2 \to \alpha\psi$

↪ Mixtures — ambiguous for physical components only when eigenvalues of ρ are degenerate.

$|u_1\rangle\langle u_1| + |u_2\rangle\langle u_2|$

$\to |\alpha\phi_1 + \alpha\phi_2\rangle\langle\alpha\phi_1 + \alpha\phi_2| + \ldots$

$|\alpha|^2 \phi_1\phi_1 + |\alpha|^2 \phi_2\phi_2 + \quad \alpha_2\phi_1\phi_2$

$$\alpha\rho_1 + \beta\rho_2 = \gamma\rho_1' + \delta\rho_2' = \rho$$

$$\alpha^2\rho_1 + \beta^2\rho_2 = \alpha^2\rho_1' + \beta^2\rho_2'$$

$$\gamma = \alpha \quad = \alpha\rho_1' + \beta\rho_2'$$

$$\alpha(\rho_1 - \rho_1') = \beta(\rho_2 - \rho_2')$$

α

use (P1) and write eq. no's on left (1) unto equation.
(P2)

on P1:

Bunge, M. "Physical Time: The Objective and Relational Theory. Philosophy of Science. 35, 1968, pp. 355 – 388.

Quote: If a process is T-invariant then its laws are T-invariant

Converse is not true.

cylinder $x^2+y^2=1$
and the plane $z=0$.

~~chalmers does not discuss leibniz relative to gravity~~

Boolean algebra . J. Bell

Smallest filter containing subset X of B is said to be generated by X. Principal filters are generated by single elements

$\{y \mid x \leq y\}$ is principal filter of x.

hull of homomorphism is $\{x \in B \mid h(x) = 1\}$

kernel . . . . . $\{x \in B \mid h(x) = 0\}$

Ultra filter is a filter which is not contained in any other filter.

F is an ultra filter $\Longleftrightarrow$ F is the hull of a homomorphism $h : B \to \underset{\sim}{2}$

minimal Boolean algebra $\{0,1\}$

Minimum Boolean algebra $\underset{\sim}{2} = \langle 2, \leq \rangle$ where $2 = \{0, 1\}$.

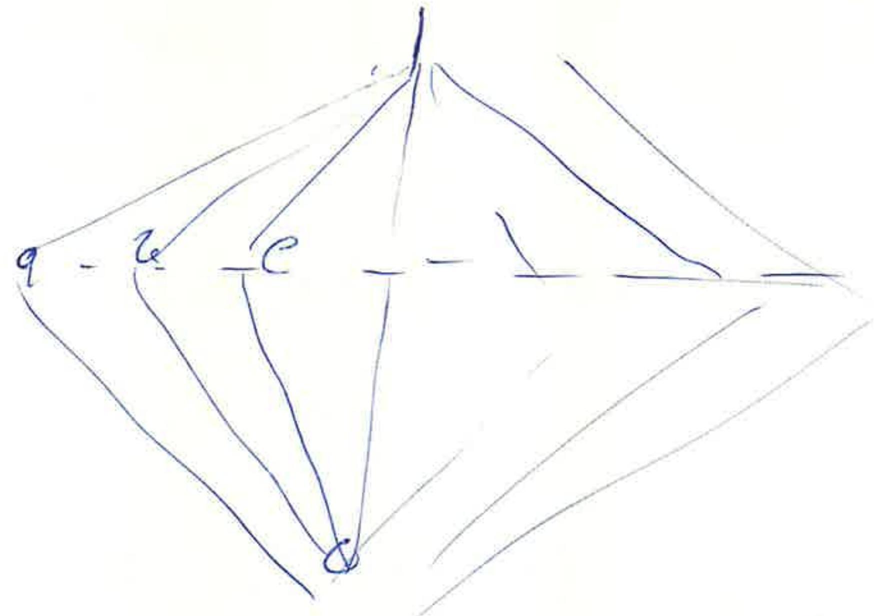
Complemented lattice $\begin{cases} \forall x \in L, \exists y \in L \text{ s.t.} \\ x \vee y = 1, \ x \wedge y = 0 \end{cases}$

Distributive law $x \wedge (y \vee z) = (x \wedge y) \vee (x \wedge z)$

and $\Rightarrow$ $x \vee (y \wedge z) = (x \vee y) \wedge (x \vee z)$

<u>Boolean algebra</u> is a complemented distributive lattice

<u>Ex</u>



corresponds to 2-dimensional Hilbert space
is <u>not</u> a Boolean lattice since:

a and (b or c) = a

while (a and b) or (a and c) = 0 or 0 = 0.

Fluctuations in electrical circuits
the Johnson Effect cf. (as opposed to the Shot effect in a vacuum Tube)
Barnes & Silverman R.M.P. vol 6 p. 162 (1934)

References on Irreversibility
Grunbaum: Philosophical problems of space & Time
Reichenbach: The Direction of Time
— [illegible] Branch systems entertained by Schrödinger
refers to Popper Nature.
Schrodinger's branch systems Proc. Royal Irish Academy 53 (1950) p. 189
Penrose & Percival. Proc. Phys Soc. 79 (1962) p. [illegible]
[illegible]

Davies the Physics of Time Asymmetry (Surrey Univ. Press 1974)
Gold ed The Nature of Time (Cornell Univ. Press 1967)

C Gale: Chemis Cosmology.
Journal of the History of Ideas 35 (1974) p339

Weinberg Gauge Theories R.M.P. 46 (1974) p255.

Penrose The Structure of Space-time
in Battelle Rencontres
1967 Lectures in Maths & Physics
Ed. deWitt & Wheeler 1968
(Good acc of history of singularities
& grav. collapse – refers
to Hawking and extent
of later Einstein seriously)

Park: Int. J. theor. Phys. 8 (1973) p. 211

queries ~~coherence interpretation & neutrinos~~

Fino P.R. D2 2783 (1970) extends Wigner's proof of no velocities (+ d'Espagnat etc)

Moldauer P.R. D5 1028 (1972)

Reply by Fino P.R. D5 1033 (1972)

refer to Wedlich for appearance etc.

Z. Physik. 205, 199 (1967)

Haake & Wedlich 213, 451 (1967)

Neumann a.a. 17.

Fekis ? Shimony P.R. D 9 (1974) p 2317
Shimony P.R. D 9 (1974 p 2321

~~explicaní~~ ukázat a vyjádřit rozdíl

Green: N.C. 9 (1958) p 880

considers the effect of detecting well separated beams (as in Stern Gerlach) using a macroscopic apparatus (photo plate) or a metastable state. Explains how interference terms are eliminated, similar to Bohm's random phases introduced between the beams

Jost The General Theory of Quantized Fields (1965)

For Dirac 1927 "success & failure were immediate"
"The success" Dirac was able to derive ... to understand
rationally the already familiar rules describing the
emission & absorption of light. The failure: P. Ehrenfest
... immediately pointed out that the theory had
to lead to ∞'s because it contained as an
essential quantity the value of the vector potential
at the position of the point-electron".
cp Pauli W. Naturwissenschaften 21 (1933), 841.

Renormalization has its roots in Heisenberg, Dirac & Weisskopf
in the mid-thirties Z. Phys. 90 (1934) 209
Mat Fys Medd Danske Vid Selsk 14 (1936) no 6

We do not know if axioms are compatible with a
non-trivial S-matrix, but they do exclude QED
because of [illegible] on 'gauge-invariant' [illegible]

Jost discusses PCT theorem & connection
between spin-statistics
— also "abnormal" commutation relations.

Comments from the Philosophy of Karl Popper
The Library of Living Philosophers ed. P.A. Schilpp
published by La Salle, Illinois. Open Court. 1974

Very good autobiography stresses argument with Schrodinger about irreversibility (arrow of time due to thermodynamics)

Bronowski stresses a symmetry between falsification & verification for probability statements, refers to Neyman Pearson, Popper denies this & refers to his theory of random finite sequences which maintains the asymmetry.

Lakatos ~~says~~ "Popper on Demarcation & Induction" pp. 241–273. says on p. 242. "the term "normative" no longer means rules for arriving at solutions, but merely directions for the appraisal of solutions already there"
Footnote 5. "I should like to say here that I always had doubts about whether this (no doubt progressive) problem-shift had not gone a bit too far. —
I have held that there might well be a limbo for a "genuine" heuristic which is rational & nonpsychologistic; refers to Proofs & Refutations p. 4, n. 4. (B.J.P.S 14 1963/64)

Medawar Hypotheses, Imagination, reprint from the Art of the Soluble, 1971 p. 274–291.
stresses the fore-runners of Popper in the hypothetico-deductive methodology – cites Whewell, Jevons as opposition to the inductivism of Mill & Pearson
Section IV discusses heuristics "what scientists do has never been the subject of a scientific, that is, an ethological enquiry. – no use looking at scientific papers – they conceal, indeed actively misrepresent the reasoning that goes into the work they describe. One do not listen to what scientists say they do.
"The weakness of hypothetico-deductive system, insofar as it might profess to offer a complete account of the scientific process, lies in its disclaiming any power to explain how hypotheses come into being"

Eccles explain how Popper's philosophy prompted him to falsify his own hypotheses

Watkins gives account of indeterminacy – distinguishes metaphysical determinism and scientific determinism
Causality   possibility of scientific prediction

Musgrave writes on Popper philosophy of Science & Suppes suggests statistical features of Q.M. are very non-standard (no joint distr. in general). Grunbaum gives good account on arrow of time. refers to his book Philosophical problems of space & time (1964)

Boyle very good account in favour of the Open Society – distinguishes "utopian" and "piecemeal" social engineering.

Quote from Poverty of Historicism p. 141
"What may be called the method of logical or rational construction, or perhaps the 'zero method' – the method of constructing a model on the assumption of complete rationality (and perhaps also on the assumption of the possession of complete information) on the part of the individuals concerned, and of estimating the deviation of the actual behaviour of people from the model behaviour, using the latter as a kind of zero coordinate."

In the bibliography reference is made to
Popper, 1974, Philosophy and Physics: Essay in
defence of the objectivity of Physical Science.
p. 413–463

Donald Campbell gives outlook on
"evolutionary epistemology" for the part
of view of a psychologist — [illegible]
view of development or Kant's categories
— [illegible] [illegible] references
eg. C.F. Wallraff, Philosophical Theory & Psychological Fact, 1961
H. Poincaré, Mathematical Creation in The Foundations of Science 1913
P. Souriau, Théorie de l'Invention 1881
Ernst Mach, On the part played by Accident in Invention
& discovery, Monist, 6 (1896) 161–75.
Alexander Bain, The senses & the intellect, 1874
(Trial & error model of discovery)
S. Jevons Principles of Science, 1892.
Campbell discusses H. A. Simon, The Sciences of the artificial, 1969
also A. Newell, J.C. Shaw, H. A. Simon
'Elements of a theory of human problem solving',
Psychological Review 65 (1958) p. 151-66

replied to by D.T. Campbell, 'Blind variation and selective retention in creative thought as in other knowledge processes', Psychological Review 67 (1960) p380-400.
cf also K.J.W. Craik The Nature of Explanation 1943.

refers also to R. Ackermann The Philosophy of Science 1970 for extension of Toulmin's evolutionary model.
Toulmin goes → 'competing intellectual variants', concepts beliefs etc. Careers + individual Scientists

cf also G. Polya. Mathematics + Plausible Reasoning
vol. I Induction + Analogy in Mathematics
vol II Patterns of Plausible inference.
1954.

Note Campbell's distinction between 'blind' + 'random' — missed in Popper's reply

Further references on Measurement (after H. Brown)

Fine Proc. Camb. Phil. Soc. (1969) 65 111
Phys. Rev. D2, 2783 (1970)

Sneed (on Von Neumann) Phil. Science 33 (1966) p. 22
Also use of Compton-Simon expt to justify the Projection Postulate

Furry "Some aspects of the Q. Theory of Measurement" in Lectures in Theoretical Physics Vol VIII-A
Univ. Colorado Press (1966) p. 47

Park Int. J. Theor. Phys. (1973) 8, 211

Wigner R. M. P. 37, ~~19~~595 (37) (Phys II)
(Giovanoree)

Popper : Nature, 219, 682 (1968)
on Birkhoff, von Neumann's a/c
of Q. Mechanics (Phys. 30

Fine (Q. Rech. 22)
Probability in Q. Mechanics

Rorla, Specker QM 27

Park, Margenau Q.M. 37.

Fraven Q.M. 45

Gibson Q.M. 2. Statistical theory of Q. Mechanics

Feyl Q.M. 3 Low prob.

References (additional) ✓ Jauch H. Phys. Acta (1964) 37, 293 ✓

Measurement

✓ Daneri, Loinger, Prosperi Nucl. Phys. 33 297 (1962) ✓
Nuovo Cimento 44B 119 (1966) ✓
✓ Rosenfeld S Prog. Th. Phys. - 222 (1965) ✓
George, Prigogine, Rosenfeld. ~~Mat. Fys. Medd. Dan. Vid. Selsk.~~ Det. Kgl. Danske Vid. Selsk. Mat. Fys. Medd.
Nature: vol. 240 (1972) pp. 27 Nov. 72,
Hepp. Helv. Phys. Acta. 45 237 (1972) vol 38 no 12 (1972)

Kripps Nuo Cim. 1B (1971) p 23 & others ✓
63B6 (1968) p. 1127
60B (1969) p. 278 ✓, 61B (1969) p 22 ✓
Phil. Science 36, (1969) p 145.

Joint distributions
✓ Prugovecki Canad. J. Phys. 45 (1967) p 2173 ✓

Hidden variables
Bell R.M.P. 38 447 (1966) ✓
Physics 1, 195 (1965) ✓
Gleason: J. Math. Mech. 6, 885 (1957)
Clauser, Holt, Horne, Shimony PRL 23 880 (1969) ✓
Kocher, Commins: P.R.L. 18, 575 (1967) ✓
Freedman & Clauser P.R.L. 28, 938 (1972) ✓

(S-matrix Aurous Chew Physics 1 p. 77) ✓

Q. Logic

Putnam: Beyond the Edge of Certainty

Gardner Phil. Sci. 38, 508 (1971)

Heelan. Synthese 21 (1970) p 2.

Landé: Foundations of Q. Theory 1955

New Foundations of Q. Mechanics 1965 LX

Bell LX on Davies etc N. Cim. 57 B (1968), 503

Bell on hidden variables & Gleason's theorem

B S & S 19 (1968) p. 185 LX

Bohm & Bub R. M. P. 38 (1966) p 453. LX

Bohm P.R. 85 (1952) p. 166, 180 LX

Bohm & Aharonov: Experiment on EPR non-locality

P.R. 108 (1957) p. 1070.

Papaliolios Test of 1st kind hidden variables

P. R. L. 18 (1967) 622. LX

Wu & Shaknov P.R. 77, 136. (1950)

Kasday

Bohr P.R. 48 (1935) p 696

Furry P.R 49 (1936) p 393

Hove: Physica 21 517 (1955) ✓
25 268 (1959) ✓

Rosenfeld Nucl. Phys. A 108, 241 (1968) ✓

Javel, Wigner, Yanase Nuovo Cim. 48 B (1967) p. 144 ✓

Singer Nucl. Phys. A 108 p. 245 (1968) ✓

Peres & Singer N.C. 15 (1960) p. 907

Daneri + Prosperi, Loinger Nucl. Phys. 33 297 (1962)

explain relevance of ergodicity – approach to equilibrium state by taking time averages over fluctuating states. Measurement is then referred to approach to ergodicity in Bocchieri, Loinger. P.R. 114 (1959) 948.

micro state $\xrightarrow{\text{superposition}}$ macro state $\xrightarrow{\text{ergodic development}}$ [illegible]

superposition

↳ irreversibility destroys initial correlation on the atomic scale.

Daneri, ~~Pro~~ Loinger, Prosperi Nuovo Cim. 44 B 119 (1966)

discuss specific example of scintillation counter, spark chamber. answer criticisms – attacks Jauch for ignoring the amplifier

Rosenfeld Supplement Prog. Theor. Phys. (1965) p. 222–231

"The Measuring Process in Q. Mechanics".

gives very clear account of the Italian argument:

– completes Bohr's approach.

Bub Nuov. Cim. 57 B (1968) 503
attacks the Italians — very clear summary of their work, but his suppose Bohr's views — do not prove them.

Jauch Helv. Phys. Acta (1964) 37, 293
His explanation is not valid partial measurement process — it is the defn of macroscopic observables, same discussion as in his book.
Mixtures can always be distinguished from superpositions by some measurement (this is not denied)

Hove Physica 21 (517) (1955)
discusses derivation of transport equations describing irreversible approach to statistical equilibrium of a system with many degrees of freedom.

Hove Physica 25 268 (1959)
continues with discussion of the ergodic behaviour of q. many-body systems

Rosenfeld Nucl. Phys. II 108 p. 241 (1968)
defends the orthodox Bohr theory of measurement
– discusses the consistency problem for measurement, praises the Helene and attacks Jovel Wigner, Yanase

refers to Ingraham. N.C. 9 (1958) 99 for claim that Hove's results violate Unitarity. (also attacks Prigogine Brout)
– denied by Van Hove

Loinger Nucl. Phys. A 108, p 245 (1968)
defends the Italians against Jauch, Wigner, Yanase.

Jauch, Wigner & Yanase. Nuo. Cim. 48 B (1967) p 144
give a very clear general account of their objection to the Italians:

1st the measurement is not to be sought in the macroscopic part of the measuring process
- ergodic development which takes [illegible] place.

Jauch believes ~~that~~ "classical" has [illegible] observable superposition for real physical systems - classical systems have a restricted class of observables.
(e.g. only those observables which cannot "see" A)

They discuss further the possibility that Q. mechanics does not apply to macroscopic bodies

Bohr Can Quantum Mechanical Description of Physical Reality be considered complete?

$[q_1, p_1] = [q_2 p_2] = i$ etc write $q_1 = Q_1 \cos\theta - Q_2 \sin\theta$

$p_1 = P_1 \cos\theta - P_2 \sin\theta$ etc (rotation)

then $[Q_1, P_2] = 0$ so we can measure Q_1, P_2 together

But $Q_1 = q_1 \cos\theta + q_2 \sin\theta$

$P_2 = -p_1 \sin\theta + p_2 \cos\theta$

∴ knowing Q_1, P_2 we can measure q_1 from q_2 or p_1 from p_2

This is true form of EPR paradox

"influence on the very conditions which define the possible types of predictions regarding the future behaviour of the system" these conditions constitute an inherent element of the description of any phenomenon to which the term "physical reality" can be properly attached

Bell Physics I ; 195 (1965)

given illustration of hidden variable theory for spin $\frac{1}{2}$ — discusses the Bohm-Aharonov form of the E.P.R. paradox — introduces the locality assumption and then derives the Bell inequality contradicting the predictions of Q. Mechanics

Hepp Helv. Phys. Acta. 45 237 (1972)

discusses measuring apparatus having ∞ no. degrees of freedom.

$\mathfrak{A} \subset B(\mathcal{H}_S \times \mathcal{H}_A)$

we require $(\psi_+ \otimes \phi_+, A\, \psi_- \otimes \phi_-) = 0$.

for all feasible observations A.

Hepp He does not use time averaging to cancel phases.

coherence → disjoint states at ∞ times

when coupled to a q. apparatus with ∞ no. of degrees of freedom

So. Hepp uses causality of the apparatus:

|

Krips N.C. 6 1127 (1968)

Requirement of objectivity:

$\sum C_n |\phi_n\rangle \times |\psi_n\rangle$ is not correlated. why(?)

since ϕ_n eff. Ran in ψ_n

Define $\overline{W}_t^{S+M} = \int_{t'-\tau/2}^{t'+\tau/2} dt\, W_t^{S+M} = \int_{t'-\tau/2}^{t'+\tau/2} \sum_{nn'} C_n \bar{C}_{n'} |\phi_n(t)\rangle\langle\phi_{n'}(t)| \times |\psi_n(t)\rangle\langle\psi_{n'}(t)|$

where $|\phi_n(t)\rangle \times |\psi_n(t)\rangle = \exp\left[\frac{-iH^{S+M}}{\hbar}(t-t')\right]|\phi_n\rangle \times |\psi_n\rangle$

$\underset{\sim}{\longrightarrow} \sum_n |C_n|^2 |\phi_n\rangle\langle\phi_n| \times |\psi_n\rangle\langle\psi_n|$

N.C. 6 B 13 (1969) 278.

Proving elimination of $c_i \bar{c}_i$ terms on p 289 by time averaging

N.C. 1B (1971) p.23

Paradoxes arising in density matrix required for the energy of system on a particular occasion can have 2 "values" — we do not say state as a unique ket for a system at time t for the system

Griffiths N. Cim. 60B (1969), 278,
61B (1969), 12.
1B (1971), 23

discusses new accurate approach to measurement theory

<u>Krips</u> Phil Science, <u>36</u>, 145 (1969)
discusses Cat - & E-P-R. — obscure argument to follow.

refers to
<u>Sharp</u> Phil. Sci. <u>28</u>, 225 (1961)
who suggests interaction between cl & test
systems never really vanishes
— very poor argument, but supported
by Putnam in an accompanying note.

S.B. suggests there is nothing in the theories
to say $x > p$ for a <u>particular</u> particle
cannot be ~~[illegible]~~ assigned previously (cf Popper)
(→ may not be trouble)
↳ Cat + photon is not a pure system.

Landé New Foundations of Q. Mechanics

attacks the duality applied to Q. Mechanics electrons are particle subject to a 3rd Q. law (after Duane (1923) which explains the reciprocal deflection (diffraction) of the electron particles in terms of a restriction on possible momentum exchanges $\Delta p = h/L$. // periodic structure L

2 slits have a different periodic structure from 1 slit. Hence different deflections of the electrons must occur.

It is not the electron which is spread out but the "Fourier components" of its screen defined on all the openings — it is this which controls the pattern of electrons behind the screen. screen acts on the electron as a mechanical unit.

Lando' stories that his work is directed
towards the demystification of D. Nedelcu's

George, Prigogine, Rosenfeld

Dat. Kgl. Dansk. Vid Selsk. Math Phys Medd

vol. 38, no 12 (1972)

Varadarajan — The Geometry of Q. Theory

discusses the logic of Q. Mechanics as in Jauch
defines observable, state:
& proves Gleason's theorem in some detail
all states can be described by density matrices

In second volume he deals with symmetries
— similar treatment to Jauch.

Bohm Q. Theory

exp measurement → place factors
gives example of Stern Gerlach —
interference or "recombination" of spins
infeasible in practice → restores thermodynamic argument

~~Bohm~~ Bell R.M.P. 38 447 (1966)

explains hidden variable example for 2 dimensional space.

- contradicts Von Neumann assumption.

refer to Gleason. - no dispersion possibles if

additivity argument is imposed on commuting operators. → result of a measurement same independent of what other measurements are being made.

- non-locality of Bohm's solution

George, Prigogine & Rosenfeld Nature 240 p.25 (1972)

Large atomic systems best investigated in the kinetic approach of statistical mechanics not the ergodic approach. This is the difference on equilibrium of the [illegible] School.

– correlations are lost in both methods if present in the initial states

Superspace defined as direct product of H & its dual.

i.e. Linear transformations (operators) are described as Tensors ↔ direct product space.

thus $L_{\mu\nu} x_\mu x_\nu \equiv y_\nu x_\nu$ where $y_\nu = L_{\mu\nu} x_\mu$.

$L_{\mu\nu}$ is an operator.

Projection operator defined in superspace separates out $\hat{H}$-subdynamics – macroscopic level of description is the reduced description in terms of variables of the $\hat{H}$-subspace evolution in $\hat{H}$ space eliminates free correlations – they are transferred to the orthogonal space.

Human observers described entirely within the $\hat{H}$ subspace; his interaction does not influence at all the orthogonal subspace.

Velocity [illegible] coupled to average distribution [illegible], correlation functions.

refer to Prigogine: Non-Equilibrium Statistical Mechanics

Two directions of linear polarization
$\equiv$ 2 senses of circular polarization
$\equiv$ 2 values of spin in same direction

Wu & Shaknov P.R. 77 136 (1950) 2 photon decay of e⁺e⁻ pair — correlation of polarizations

discusses angular correlation of annihilation radiation agrees with predictions of Q Mechanics

Aharonov & Bohm P.R. 108 (1957) p. 1070

discusses the Wu-Shaknov experiment as a possible test of the E.P.R. paradox

— calculate correlation assuming 1) Q. Mechanics 2) photons → neutrons when wave-packets do not overlap. (1) is confirmed by the experiment

Peres & Singer N.C. 15 (1960) p. 907

reject photon-polarization as test of a paradox — they regard this case, attributed in Einstein's terms as a "deeply unsatisfactory" a photon cannot be circ. polarized & linearly polarized at the same time.

they recommend experiment on 2 spin ½ particles

Zet de platen [illegible].

Bohm & Aharonov N.C. 17. 964 (1960).

reply to Peres and Singer, by pointing out that we measure energy flux associated with a polarization in field theory.

Thus linearly polarized wave does possess circular polarization and vice versa.

– their argument is probably correct

classically I_{k1}, I_{k2} can be measured as well as I_{k+}, I_{k-}, but in Q.M. these flux operators do not commute

$$I_{k1} = \frac{p_{k1}^2 + q_{k1}^2}{2} \qquad I_{k+} = \frac{(q_{k1} - p_{k2})^2 + (q_{k2} + p_{k1})^2}{2}$$

$$I_{k2} = \frac{p_{k2}^2 + q_{k2}^2}{2} \qquad I_{k-} = \frac{(q_{k1} + p_{k2})^2 + (p_{k1} - q_{k2})^2}{2}$$

$$A_k = \left(q_{ki}\cos(kx) + p_{ki}\sin(kx)\right)\frac{\epsilon_{ki}}{\sqrt{k}}.$$

q_k, p_k do not commute.

Gleason J. Math. Mech. 6 (1957) p. 885

Proves as his main theorem.

For any measure μ on the closed subspaces of a closed (real or complex) Hilbert space of dimension at least 3, there exist a semi-definite self adjoint operator T of the trace class such that $\mu(A) = \text{Trace}(TP_A)$

P_A is projection operator.

difficult mathematical proof

Frame functions

$\sum f(x_i) = W$

orthonormal basis

f is regular if $\exists$ self adj. such that $f(x) = (Tx, x)$

Every non-negative frame function in 3 or more dimensions is regular

— these result leads to the main theorem

Belinfante: A Survey of Hidden Variables Theories

Three kinds of theory : Zeroth kind involve self-contradictory postulates

First kind agrees essentially with Q. Mechanics e.g. Bohm

Second kind look like causal theories when applied to spatially separated systems which interacted in the past. — contradict Q. Mechanics

2 reasons for dissatisfaction with Q. Mechanics

1.) "If different members of ensemble E_ψ are found after measurement to have different values A_i of an observable A, then these individual systems must have been in different microstates"

additional hidden parameter ξ then measurement of ξ (i.e. knowing ψ) ξ selects ϕ_n

$$\psi \to \phi_n \quad \text{with} \quad n = n(\psi, \xi, \{\phi_i\})$$

Gleason, Kochen, Specker show that dependence on $\{\phi_i\}$ is essential.

2.) Non-locality aspect of Einstein, Podolsky, Rosen, measurement of 1 at F_1 depends on 2 at F_2.

RTW

Hidden variables do <u>not</u> tell us what are the values of certain observables. They tell us what <u>would be found</u> if we measure those observables in a certain way.

B. then deals with Zeroth order theory of Von Neumann, Kochen & Specker, Gleason, Jauch & Piron.

K–S dealt with this :– paradox arises for assuming for any value of ξ we can predict value of $J_n^2(\xi)$ without mentioning other 2 ⊥ directions.

dependence of n on $\{\Phi_c\}$ is discussed by
~~Turner~~ Turner (1968) J. Math Phys. 9, 1411
cf also Rassid (1966), N. Cim. 47 841

B then deals with <u>1st order theories</u>

viz Bohm, Wiener & Siegel, Bohm & Bub & the experiments of Papaliolios for verifying these – failed to disprove Q. Mechanics

B continues by discussing theories of the 2nd kind

& discusses the experiments of Kocher & Commins, & Clauser & Holt using 2-photon correlations for an atom cascading towards its ground state.

They also discuss experiments where 2 photons are produced by an annihilating positronium atom

– Bleuler & Bradt, Wu & Shaknov, Langhoff, Kasday, Ullmann & Wu.

– Refers to Furry (1936) & Bohm & Aharonov (1957) for how non-locality may be avoided, breakdown of Q. Mechanics for many-particle systems at macroscopic separations – pure states → mixture

Araki & Yanase P.R. $\underline{120}$ (1960) p. 622

refer to Wigner Z. Physik $\underline{131}$, 101 (1952)

we cannot measure quantities which do not commute with a conserved ideally quantity e.g. x component of spin if z component is conserved.

approximate measurement is possible if apparatus is so large that it is a superposition of many states with different e.v.'s of the conserved quantity.

$L = L_1 \otimes 1 + 1 \otimes L_2 \qquad [U(L), L] = 0$.

L is conserved. we want to measure M.

$V(t)\, \phi_{\mu\ell} \otimes \xi = \sum_{\ell'} \phi_{\mu\ell'} \otimes \chi_{\mu\ell\ell'}$

this is inconsistent unless $[L, M] = 0$ this is proved

$M \phi_{\mu\ell} = \mu \phi_{\mu\ell} \qquad (\phi_{\mu\ell}, \phi_{\mu'\ell'}) = \delta_{\mu\mu'} \delta_{\ell\ell'}$ eu degeneracy index

$(\chi_{\mu\ell\ell''}, \chi_{\mu'\ell'\ell''}) = 0, \ \mu \neq \mu'$.

approximate measurement is then discussed. large eigenvalues of conserved quantity must be possessed by the apparatus — argument for macroscopic apparatus RTD

where

$$\left(\phi_{\mu\epsilon}\otimes\xi,\ L\ \phi_{\alpha}\otimes\xi\right)$$

$$= \left(U(t)(\phi\otimes\xi),\ U(t)L(\phi\otimes\xi)\right) \quad UU^{+}=1$$

$$= \left(U(t)\phi\otimes\xi,\ L\ U(t)\phi\otimes\xi\right) \quad \text{since } U(t) \text{ commutes}$$

$$= \sum_{\chi}\left(\phi\otimes\chi',\ L\sum_{\chi'}(\phi\times\chi')\right) \quad \text{by measurement efficacy.}$$

If $L = \cancel{L\otimes 1 + 1\otimes L}$ ~~or else~~. $L_1\otimes 1 + 1\otimes L_2$ or else.

then. L.H.S. $= (\phi', L\phi)(\xi\xi') + (\phi',\phi)(\xi, L_2\xi)$

R.H.S. $= \sum_{\chi'\chi''}(\phi' L,\phi'')(\chi',\chi'')$

$+ (\phi',\phi'')(\chi' L_2\chi'')$

Then if $\mu'\neq\mu$ $(\phi'_{\mu} L,\phi_{\mu}) = 0$.

where L_1 commutes with the ϕ's are eigenfunctions of M.

Yanase P.R. 173 (1961) p.660

étude de simple couche et région

σ_x mesuré, σ_z constant, obt

les conditions pour un "apparente" moment.

Beck & Nussenzweig N.C. 9 (1958) p 1068

electron diffraction by a slit

— they conclude uncertainty relations are

not contradicted even if a narrow slit.

explain that

$$S_{p_y}(\infty) \cdot S_y(0) \ll 1 \text{ for a narrow slit}$$

but this does not contradict H, since we ought to

compare $S_{p_y}(0) \cdot S_y(0) \approx 4.6$ — satisfies

H's relation.

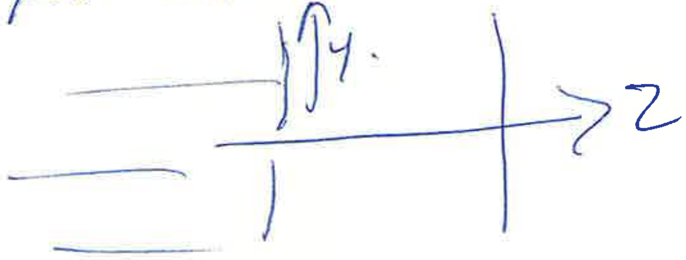
B & N show that st. mean sq. dev. Δy, Δp_y

are such that $\Delta p_y(0)$ diverges logarithmically

for a narrow slit — suggest using $\Delta_y \delta$

the "½ width" of the prob. distribution in the plane

$z = \zeta$



D'Espagnat (1966) N. Cim Supp 4 828 (1966)

refers to Wigner Am J. Phys. 31, 6 (1963)

for proof that existence of states for apparatus does not solve measurement problem.

What about non-ideal measurements.

Wigner's proof is extended to these cases.

37 TU 235 0

— also the question of the pointer position not finally in a completely (p=1) state is considered — shown to fail.

D'E. refers to Landau, Lifschitz Q.M. (1958) for discussion of non-ideal measurements.

(does not refer directly to Araki-Yanase, but to Wigner (1952) by footnote

Earman, Shimony N/C. 54 B 332–334

'A note on Measurement'.

extends D'Espagnat's result to the

case of degenerate eigenvalues for object.

Tomonaga Quantum Mechanics 1966. North-Holland

p. 231 – 238 He gives a time-dependent account of diffraction & interference in a 2-slit experiment.

Since $\Delta y \, \Delta p_y \gg \hbar$ for deviation at the screen & $\Delta y \, \Delta p_y \geq \hbar$ for initial packet (uncertainty product increases with time, does not remain stuck at a minimum value.

Landau & Lifshitz Quantum Mechanics

discuss on p. 21 the question of how measurement "disturbs" a state — they do not use the term non-ideal measurement.

Bunge Foundations of Physics.

p. 265 states "Not every actual calculation for such idealized situations happens to confirm Heisenberg's relations (Bohr & Rosenzweig 1958)"

Springer-Verlag (1967)

Proceedings of the International School of Physics «Enrico Fermi»

Course 49 Ed. B. d'Espagnat, Academic Press.

Foundations of Quantum Mechanics

Stein H. & Shimony A. Limitations on Measurement. pp 56-74.

Wigner's article 6 views on collapse of state-vector

1.) no collapse see Everett
2.) classical measuring instruments
3.) Q.M. does not apply to macroscopic systems of tendency
4.) collapse is an outer axiom of Q.M.
5.) Environment because of the chances no need to "explain" collapse.
6.) systems never actually separable

Stein & Shimony generalize the Wigner-Araki-Yanase result & give new proof of the Araki-Yanase result for the soln of measurement problem.

Bohm's phase argument

we have $\psi = \quad \nu_+ f_+(z,t) + \nu_- f_-'(z,t)$.

$$\to \nu_+ e^{i\alpha_+(z,t)} + \nu_- e^{i\alpha_-(z,t)}$$

$\alpha_+(z)$ $\alpha_-(z)$ are very large phases.

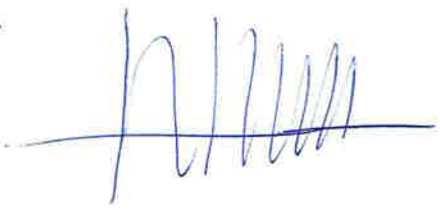
we know that $\int dz \; f_+^*(z) f_-(z)$ is very small

for good measurement.

$$\hookrightarrow \int dz \, e^{i(\alpha_+(z) - \alpha_-(z))}$$

these phases $\to \int dz \, e^{ikz}$ der k very large.

$\to 1/k$ very small.

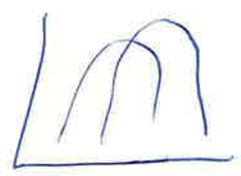


This applies as seen as beam

leaves the magnet

— as beam $\to$ seen 2 blue islands in space

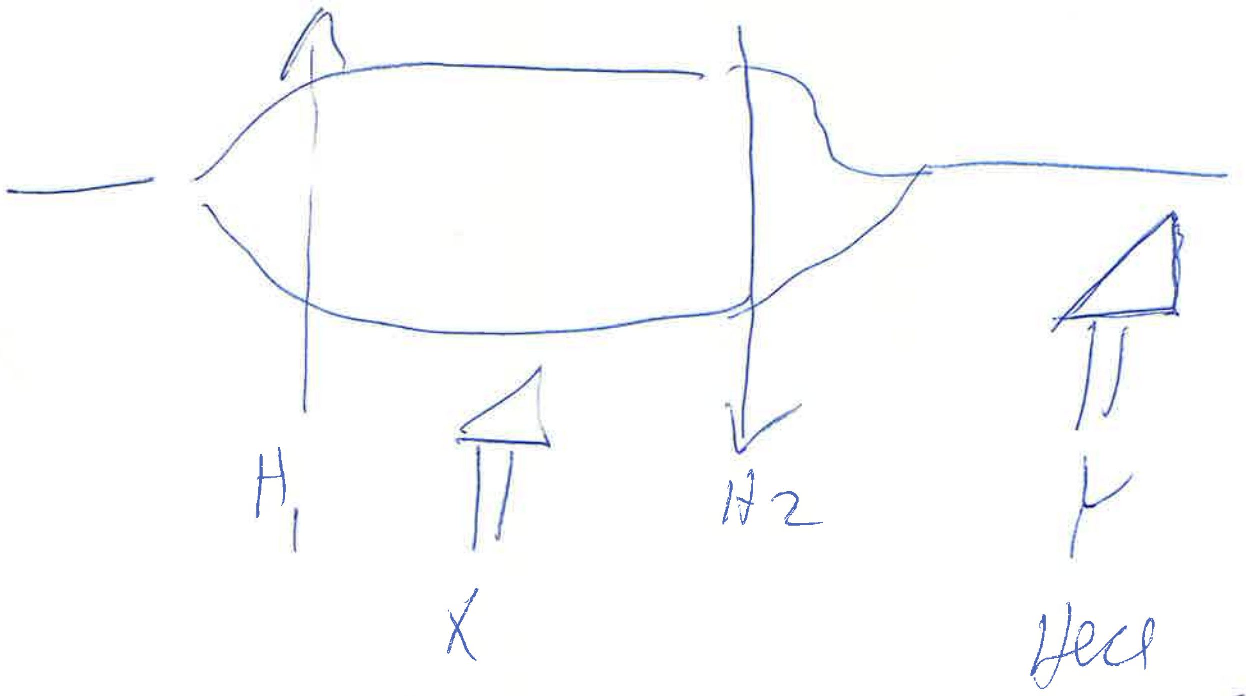
as well



long magnet
the wavefunction
due to large phases

otherwise
the wavefunctions
are to be
overlap.

What Bohm fails to prove



Here
$\langle \sigma_x \rangle = 0$ by Bohm
1 by Q.M.

Here
$\langle \sigma_y \rangle = 0$ by Bohm
$= 1$ by QM.

Bohm gives no calculation to reconcile the contradiction between the phase argument and QM for measurement at Y.

Suppes Phil. Sci 28 318 (1961)

Margenau, Park Int. J. Theor. Physics 1, 211 (1968)

Fine Br. J. Ph. Science. (1973)

Park Phil. Science. 35 205, 389 (1968)
Found. Physics 1, 23 (1970)

Heelan Q. Logic. Found. Phys. 1, 95 (1970)

Feyerabend Pittsburgh Studies vol 3 1962

Linart Nuovo Cimento (1972). (Suitability; determination). 13 A no 2, 355

Tisza R. M. P. 35 no 1 (1963)

Baker & Glashow Proton spin... P.R. 128 2462 (1962)

Lee Review article on symmetry in :-

Journals Philosophy of Science
Synthese
Scientia
Brit. J. Phil. Science
Foundations of Physics

Suppes (1961) Phil. Sci. 28 378.

Discusses joint probability distributions characteristic function for 2 variables is

$$\phi(u,t) = \cancel{Exp}\ E\left(e^{itx + iuy}\right)$$

then

$$f(x,y) = \frac{1}{4\pi^2}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} e^{-itx-iuy}\,\phi(t,u)\,dt\,du.$$

where

$$\phi(t,u) \equiv \left(\psi, e^{i(up + tq)}\psi\right)$$

then for harmonic oscillator in ground state $f(x,y)$ is ≥ 0, genuine or proper prob. density but not in excited state.

Cohen (1966b) Phil. Sci 33, 317.

presents more detailed arguments relating to Margenau, Cohen's paper on Q. Th. probability.

The general form of $F(q,p)$ is referred to properties of the characteristic function

$$M(\theta,\tau) \rightarrow \sigma(\theta,\tau)\, M_q(\theta)\, M_p(\tau)$$

defined $\sigma(\theta,\tau)$.

then $F(q,p)$ is defined in terms of $\sigma(\theta,\tau)$

to Gud Tool to Cole, Rayomen's result.

The infeasibility of a stochastic theory is demonstrated from the special case.

$\pi(g(q,p)) = g^2(q,p)$

then $g^{(2)}(q,p) \neq g^2(q,p)$

Refers to Bohm's theory as analogous to Brownian motion, resp. his objection applies to Bohm's theory i.e. it cannot change completely it would contradict Q. Mechanics

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Rayomen still called

Starting from $\mathrm{Cov}\cdot XY = \langle 2^{|}X\,Y|4\rangle^2 - \langle X\rangle\langle Y\rangle$
$\langle 2 | \frac{XY+YX}{2} | 4\rangle^2$

they derive $P(q,p)$ for $\mathrm{Cov}\,XY = \sum P(x,y)\,x_i\,y_i - \bar{x}\,\bar{y}$

but find negative values

Cohen (1966a) J. Math. Phys. 7, 781 (1966a)
derives general form for $F(p, q)$
Starts with $F(p, q)$ → characteristic function
↳ expand in terms of moments
↳ apply correspondence rule.
of general form.

Wigner (1932) P.R. 40, 749:
joint probability distribution for $P(x_1 \ldots x_n, p_1 \ldots p_n)$ derives a quasi
which has correct marginal properties but which may be negative → & cannot be interpreted as a genuine probability.

Margenau & Hill (1961) Prog. Theor. Phys. 26, 722.
distinguishes 3 grades of causality (causal description)
1.) successive measurements give different results — completely statistical theory — cf. Margenau on Park
2) successive measurements give same but unknown result — this is Von Neumann's projection postulate
3.) measurement results are predictable.
they suggest $P(q, p) = (q, \psi)^2 (p, q)^2$ is wrong.
but $P(q, p) = (\psi, q)^2 (\psi, p)^2$ is all right but gives no correlation, but gives correct marginal distribution

Moyal (1949) Proc Camb Phil Soc 45 p 99

introduces joint probabilities using characteristic functions.
— discovers negative joint. functions — can be used as aid to calculations, but when
— ie. it is not an observable quantity.
If $F(p\,q) > 0$ at time t_0, it will remain always > 0.
$F(p,q)$ is not unique for a given state, but depends on variables one is going to measure. — first hint of Cohen's results...

Fine (1968) Ph. Sci 35, 101

distinguishes between statistical variables & random variables. The latter always have joint distributions, the former do not: & concludes non-classical logic and non-classical probability theory are not involved in Q. Mechanics

Suppes (1966) Phil Sci 33, 14

sets out the argument for non-classical logic in Q. Mechanics based on the idea that algebra of events must be such that probabilities are assigned to all events (but conjunctions of events not in general have joint probs.)
Notes that Reichenbach's 3-valued logic is not relevant to Q. Mechanics
– is not truth functional on the 3 values cited.

Boyer P.R. D8 (1973) p. 1679
Aharonov-Bohm effect
Expt. tests of Q. Mechanics

Kershaw Univ. Maryland Report (1973)
Expt tests Q. Mechanics

?) Rosenfeld Dansche - (1973 oct)
Role of measurement problem

Varadarajan   Comm. Pure. Applied Maths
15 (1962) p 189.

discusses probability in Physics
the generalization of Kolmogoroff arises when
sample space is a non-Boolean lattice.
refer to Segal Amer. J. Math 76 (1954) p. 721
for discussion of abstract probability spaces.

Segal considers algebra of random variables
→ generalizes to a non-commutative algebra

V. proves in general 2 observables do not have
a joint distribution.
x, y have a joint distribution if there exists
a σ-homomorphism z of Borel sets of plane R^2 into E.
such that $z(E \times R^1) = x(E)$ $z(R^1 \times E) = y(E)$
for all Borel sets E. (joint distribution function is $p(z(R^2))$)
V. proves joint distribution $\Leftrightarrow$ x, y are simultaneous
observable $x_\lambda = u_\lambda(x)$ is condition for this
in Hilbert space.
i.e. all x_λ's functions of some observable x

Note random variable → ensemble

$F(\Omega)$

↳ σ-Permutations.

$E \to x(E)$ is probability

probability of r.v.

having a value

is replaced by probability

of ensemble having a value.

Joint distribution is prob. of 2 ensembles

having given values and correct marginal

distributions — these are related (and

the probability measure on the ~~sample~~

space — joint distribution ~~ofer~~

to the ensembles (a generalized r.v. S)

Prugovecki Can. J. Phys. 45 (1967) p 2173

2 interpretations of uncertainty relations:

1) statistical – standard deviations in an ensemble of systems

2.) minimal error in knowledge of x & p_x of the same system after an experiment.

Heisenberg esp only here heuristic value.

W. Pauli refers to a statistical prediction

(1.) is a determinative measurement.

(2) is a preparatory measurement.

Introduces 2 probabilities

(1) probability of a joint measurement $P^{(+)}$

(2) error in determining $p^{(+)}$ (vs p^-) all for $N \to \infty$

Introduces complex probability measure.

$$P = P^{(+)} + P^{(-)}$$

Prugovecki tries to deal in general with the problem of what is meant by a joint distribution of incompatible observables by a generalization of the probability calculus which is designed for compatible observables.

Thus a probability distribution in general refers to outcome of experiment as individual errors $\to 0$ and $N \to \infty$, but for unacceptable observables the errors of the individual measurement are bounded from below; so observed distribution ever only approximate a theoretical one.
— the concept of probability must be generalized

Joint Probability distributions

Quantum Mechanics as a classical stochastic theory:

P.R. Wigner (1932)

Proc. Camb. Phil. Soc. Moyal (1949)

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Ballentine (1970) (R.M.P.)

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Nature Popper (1968)
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Van Fraassen (1973)
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Q. Logic

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<u>17</u>, 59, 1967 (63, 81, 82)
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Weale Relativistic theory of Reactions

Halpern special relativity & Quantum Mechanics ✓

Kuhn the structure of Scientific Revolutions ✓

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Pearson	Grammar of Science
Poincaré	Science and Hypothesis
Jevons	Intro. to Logic
Mach [illegible]	Mechanics
Hertz	Mechanics
Bradley	Appearance and Reality
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